CORN PLANT RESPONSES TO GROWTH REGULATORS, AS INFLUENCED BY ENVIRONMENT

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By

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TABLE OF CONTENTS

INTRODUCTION

CORN PLANT RESPONSES TO GROWTH REGULATORS, AS INFLUENCED BY ENVIRONMENT

The purpose of this study is to compare the effects of seed treatment under similar soil conditions but with differences of day length. The chemical composition of the green plants is considered, along with the size and shapes of the cells during different stages of growth. In this way, it was thought that a more definite understanding of the wide variations of results obtained in using growth regulators might be presented. Results in one environment do not seem to correspond to those in others. This approach is largely an effort to show the physiological reasons for one or two pronounced differences in growth rate.

For many years agriculturists have used different substances such as fertilizers, fungicides, insecticides, and inoculators to improve crop yields. More recently, growth regulating substances, when applied in various ways to plants may inhibit, greatly increase, or alter in various ways the growth and development of the plant (24). An effort has been made to determine the value of these in this study.

The first work with growth promoting substances dates back some eleven years, when Boysen-Jensen (7) showed that the fungus *Aspergillus niger* produced a substrate which contained a growth substance that would increase the growth rate of oats coleoptiles.

From that time until the present, many workers have presented reports and findings on numerous substances which are said to influence the growth of plants. If every substance that had been tried were listed, it would probably consist of everything within our scope of imagination. Howell (18) names a few which have been tried: juice from boiled alfalfa stems, vinegar, carbon black, sulfanilamide, paint dispersing agents, thiourea, aspirin, wine, manure extracts, shoe blacking, and so on down to complex synthetic chemicals.

Most research in this field has been in connection with rooting or cuttings from plants, using such chemicals as: indole acetic acid, indoleacetamide, indolebutyric acid, naphthaleneacetic acid, and naphthaleneacetamide (1) (3), which are synthetic products.

More recently the possibility of using synthetic chemicals for treating seeds to increase yields has been presented. Both favorable (18) (19), and unfavorable (21) (2) (23) (9) results have been obtained.

Length of Day

Several workers had previously noted the effect of day length on plants, but credit has been given to Garner and Allard (11) (12) (13) (14) (15) (16) for the discovery and demonstration of photoperiodism.

Many plants have been classified as to short day, intermediate, and long day plants. As stated by Garner and Allard:

> "a long day plant is one that ceases to flower or shows delayed or less profuse flowering, whereas, a short day plant is one that begins to flower or shows hastened or more profuse flowering when the length of day is sufficiently shortened."

The times of flowering and ripening of corn are modified by changing the length of daylight (20). Flowering of northern varieties, adapted to long summer days, is hastened when moved south. Conversely, flowering of southern varieties, adapted to the shorter summer days near the equator, will be delayed if moved north where the summer days are longer.

REVIEW OF LITERATURE

Growth Promoting Substances

The Arkansas Experiment Station (2) results show that seed treatment with various compounds had very little influence on crop yields. In only one experiment, the Atlas sorghum at the Livestock and Forestry Experiment Station, were the increases significant. In this experiment increases of 0.93, 0.88, and 0.65 tons of forage resulted from treatment of the seed with Rootone, Staleymone, and Napthalene acetic acid, respectively.

Dexter (9) made extensive plantings of hormone treated sugar beets in 1940 at the Michigan Agriculture Experiment Station. Before planting, ceresan was added to all seed and 500 pounds of 2-12-6 fertilizer was added to the soil. Seven treatments, replicated five times, were used in the tests. The beets from each plot were taken to the U. S. Department of Agriculture Sugar Beet Laboratory at East Lansing and analyses made. In every case one or the other of the control surpassed all treated plants in yield of beets per acre, per cent sugar, and yield of sugar per acre.

Ireland (19) produced favorable results on ten field crops in Oklahoma. Five hundred and eighty pounds of cotton were produced upon an acre where the seed and flowers were untreated. By treating the seed with levulinic acid and by dusting the flowers with 1% solution of the same material, 838 pounds of cotton were produced. Some yields for corn are: check plot, yield, 28 bushels; seed treated with Rootone dust, 32 bushels; corn seed treated and plants sprayed six times with Rootone, yield, 42 bushels.

Results from State college, Mississippi (23) were summarized and the conclusion reached that yields on all of the hormone treated plots were not significantly different. Neither Rootone nor levulinic acid (active ingredient in Staleymone) increased the yield of cotton, corn or soybeans. The figures presented show that there was an increase of 66% and 23.3% in yield of corn when treated with Rootone and levulinic acid, respectively, on Ocklocknee soil. On other soils, results showed considerable deviation between the treated and untreated plantings.

Kiesselbach (21) in tests at Lincoln, Nebraska, studied the effect of hormone seed treatment, using corn, soybeans, oats, and barley. Eight to ten replications were used, and the crops were grown by standard production practices. No significant benefits as to germination, seedling development, maturity, or yield were derived from any hormone seed treatment.

Howell (18) enumerates 21 ways in which plants respond to chemical treatment. Some of the more important of these are: seeds produce hair roots faster and more abundantly, larger root systems develop, fruits stay on the tree longer, and they promote faster growth.

Length of Day

Borgstrom (6) suggests that the transverse movements of food substances may be influenced by light intensities or to the exposure of the plant to varying durations. This involves the rate of food metabolism, and his implication is that the formation of amino acids and possibly of growth regulators may be closely interwoven. For this reason, it was considered advisable to introduce the two problems into the same thesis. Brogstrom shows that growth regulators and light responses may be interchangeable in plant development.

Murneek (26) used a seven hour and a fourteen hour day to study the effect of length of day on soybeans. It was found that there was a greater accumulation of dry matter in the short day than in the long day. Also, a relatively higher nitrogen metabolism and nitrogen concentration is maintained by the short day plant.

Benedict (5) exposed four species of grasses - Agropyron smithii, Bouteloua gracilis, Andropogon furcatus, and Panicum virgatum - to short days of 10 hours and long days of 18 hours. The dry weight of Agropyron smithii was not affected by the change in day length, but for the other three species the long day plants had the greater dry weight. Andropogon furcatus and Panicum virgatum had a root-top ratio greater in the short day than in the long day. The other two species were about the same for both day length.

Teosinte, Maize from Guatemala, and teosinte-maize hybrid were used by Emerson (10) to note the effect of short day and long day upon the time of flowering. The days were shortened by covering the room with heavy brown paper and the plants moved outside for 10 hours each day. Plants given only 10 hours of daylight blossomed much earlier than those exposed for the full length of day. In case of teosinte-maize hybrids the difference was usually more than two months, and for the sub-tropical maize practically one month.

The work of Sprague (27) would indicate that corn had no requirement for darkness. Corn was illuminated for 12, 16, and 24 hour period. Only a few days difference in flowering of all the corn was noted.

McClelland (22) at the Porto Rico Experiment Station, extended the day length from normal (11.3 to 12.5 hours) to 15 hours by illumination. The Porto Rican corn showed pronounced differences in growth and production under normal and 15 hour daily light exposure. Under the lengthened exposure blossoming was delayed, a much greater height was attained, and the production was inferior in number and size of ears to that under normal light exposure.

Soil and Plant

Beeson (4) has made a fairly complete review and compilation of the mineral composition of crops with special reference to the soil in which they were grown. In this publication most of the analyses have been with the plant and only the series or type of soil was given.

Wolf (28) used the rapid test to analyze 66 samples of Henderson lima beans and soil for nitrate nitrogen, available phosphorus, potassium, calcium, and magnesium in studying the relation of these elements in fruit formation. It was found that well set plants had substantially higher concentration of calcium and magnesium, but less available phosphorus than poorly set plants. Also concentration of calcium in the plants was higher where the soil had a high calcium content.

Daniel and Harper (8) determined the chemical composition of 66 samples of Andropogon furcatus and scoparius and 62 soils collected over a period of four years from 37 counties in Oklahoma. The correlation coefficient for the comparison between total calcium in the grass and the exchangeable calcium in the soil was $0.50 \pm .09$, and the correlation between the available phosphorus in the soil and the total phosphorus in the grass was $0.35 \pm .11$.

MATERIALS AND METHODS

Two varieties of June corn (one red and one white), secured from a local seed store, were used to study the effect of growth promoting substances, day length, and soil upon the corn plant. These June corn varieties are different in their responses to light and other stimuli.

Plantings

Two greenhouse plantings were made in 8-inch flower pots, one on May 10, 1943, and a second on June 25th. The first planting contained only twelve pots, because it was planned to make a field planting with corresponding treatments. Weather conditions caused the latter to fail. The second planting included twenty-four pots, twelve for a short day and twelve for a long day. A uniformly sandy, neutral leaf-mold was used for soil.

For the short-day growth, half of the pots were covered each evening at 5 o'clock and uncovered at 8 o'clock the next morning. A large cardboard box (4' x 5' x 6') was suspended by a rope and pulley over the group of pots to facilitate the handling. The plants were watered from the city water furnished in the greenhouse. A systematic rotation of the pots prevented irregularities of light.

Five corn kernels were planted in each pot, half the plantings being with red corn and the other half with white. One-third of these kernels was treated with Staleymone #16[1]; another third with copper aconitate[2]; and the last group was planted as a control. The seeds were covered with

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[1] Prepared as a commercial product by the A. E. Staley Mfg. Co., Decatur, Illinois.

[2] Prepared by a chemist of the U. S. Department of Agriculture.

the chemicals by dusting, just before planting. The powder adheres to the surface of the grains in sufficient quantities to remain during the period of seedling growth.

One seedling was taken from each pot at intervals of ten days, for sectioning and analysis, until one plant remained. This one was allowed to grow until the end of the experiment. Green weights were used as a basis for determinations. The total weight of the green plants, including the washed roots, was used in the final harvesting.

Cell Studies

For studying cell structure, two sets of free-hand sections of the first and second plantings were made. The first sections were made from as nearly the same place on the stem as possible, staining with toluidine blue, until the outer cells had absorbed enough color to be photographed. These were made by using a 6X eyepiece and a 23X apochronmatic objective. Instead of using films, exposures were made directly upon bromide paper.

Chemical Analysis

The Benjamin Wolf (29) "Rapid Determination" was used in analyzing the soil and plant tissue. Nitrate nitrogen, available phosphorus, potassium, calcium, and magnesium were determined.

Plant extracts were made by mincing fresh plant tissue (2.5 grams) and placing in a 250 ml. erlenmeyer flask and adding 100 ml. of extracting solution (25) and one level teaspoon of activated carbon. The mixture was agitated for five minutes and filtered on a Whatman No. 1 filter paper, the filtrate being reserved for the tests. At the same time 2.5 grams of minced tissue were put in the oven for moisture determinations.

Soil extracts were made by adding 12.5 grams of sieved, air-dry soil to 25 ml. of extracting solution, the mixture put in a 50 ml. erlenmeyer flask and shaken for one minute, then filtered on Whatman No. 1 filter paper, the filtrate being reserved for the tests.

Determinations of the nutrients in soil and plant extracts were made as follows:

Nitrate nitrogen. Five ml. of extract were pipetted into a series of evaporating dishes and 1 ml. of 15 per cent sodium hydroxide solution was added to each. The contents were evaporated to dryness, cooled, and 2 ml. of phenoldisulfonic acid were placed in each. The salts were then broken up with a stirring rod and again allowed to cool. The contents were diluted to 25 ml. with 15 per cent sodium hydroxide, stirred, and allowed to cool to 35° C. Photometer readings were taken immediately using a 425 mu. blue filter and adjusting to give a reading of 100 with the blank.

Phosphorus. Four ml. of ammonium molybdate and 2 ml. of aminonaphtholsulfonic acid were added to tubes containing 20 ml. of plant extract or 5 ml. of soil extract diluted to 20 ml. The contents were stirred, and after 15 minutes were again stirred, and photometer readings taken, using the 425 blue filter and a null adjustment to give 100 with the blank.

Potassium. One ml. of soil or plant extract was brought to 10 ml. volume with extracting solution. The contents were cooled to 10° C., and 1 ml. of cooled cobalti-nitrate solution was added to each. Ten milliliters of isopropyl alcohol was added by running it quickly down the sides of the tubes. The tubes were stoppered and after two minutes were thoroughly mixed. After 5 minutes, photometer readings were taken using a 650 mu. red filter and a null adjustment giving 100 per cent transmission with the blank.

Calcium. Four ml. of sodium oxalate solution were added to each tube containing 20 ml. of plant extract or 1 ml. of soil extract diluted to 20 ml. The contents were stirred and allowed to stand for 15 minutes. Photometer readings were taken using the 425 blue filter and a null adjustment to give a reading of 100 with the blank.

Magnesium. One ml. of soil or plant extract was diluted to 20 ml. with extracting solution, and 1 ml. of titan yellow and 3.5 ml. of 15 per cent sodium hydroxide solution were added to each. The contents were mixed and after 5 minutes photometer readings were taken using a 525 mu. green filter and a null adjustment giving a reading of 90 per cent transmission with the blank.

Calculations in p.p.m. were read directly from curves prepared by using varying amounts of standard solution containing known amounts of each substance.

RESULTS AND DISCUSSION

Cell Structures

Longitudinal and cross sections of seedlings from each planting were made, as shown in PLATES 1 to 8. The first six drawings are of longitudinal sections, while the last six are from cross sections. Fig. I is the longitudinal section for Fig. VII of the same plant. The other drawings are paired in the same manner. These drawings are made from the photographs of the cells, it being difficult to obtain sections by free-hand cuttings which would be thin enough to show individual cells of one layer.

Staining with an aqueous solution of toluidine blue had not only a photographic advantage, but it brought out a possibility of a glandular formation in the cell wall. Borgstrom (6) suggested that these are storage places for growth regulators. They differ from the chondriosomes of Sharp and Chamberlain in that they are not observed in the cytoplasm. These bodies appear under the medium powers of the microscope as dark colored specks in the cell walls. They are much more numerous than those in the untreated plants. If plants do have endocrine accretions, these may be the origin. Plate 6, Figure XII has the best showing of these deposits. They apparently are not a lignified structure and are not polarizable.

Generally, the seedlings from the red corn have responded more readily to growth regulators than the untreated. The longitudinal sections show this in the increased length of the cells. Borgstrom indicates that the lateral movement of substances is increased by the presence of varying degrees of light intensity or by the use of hormones. The white June corn does not show the differences as well as the red corn (compare Plates 1 and 2). It may be observed that the normal day length is more conducive to large cell development than the short days, whether the seeds have been treated or not. Other field trials have indicated that red corn responds more readily to growth regulators than white June corn.

Plant Analyses

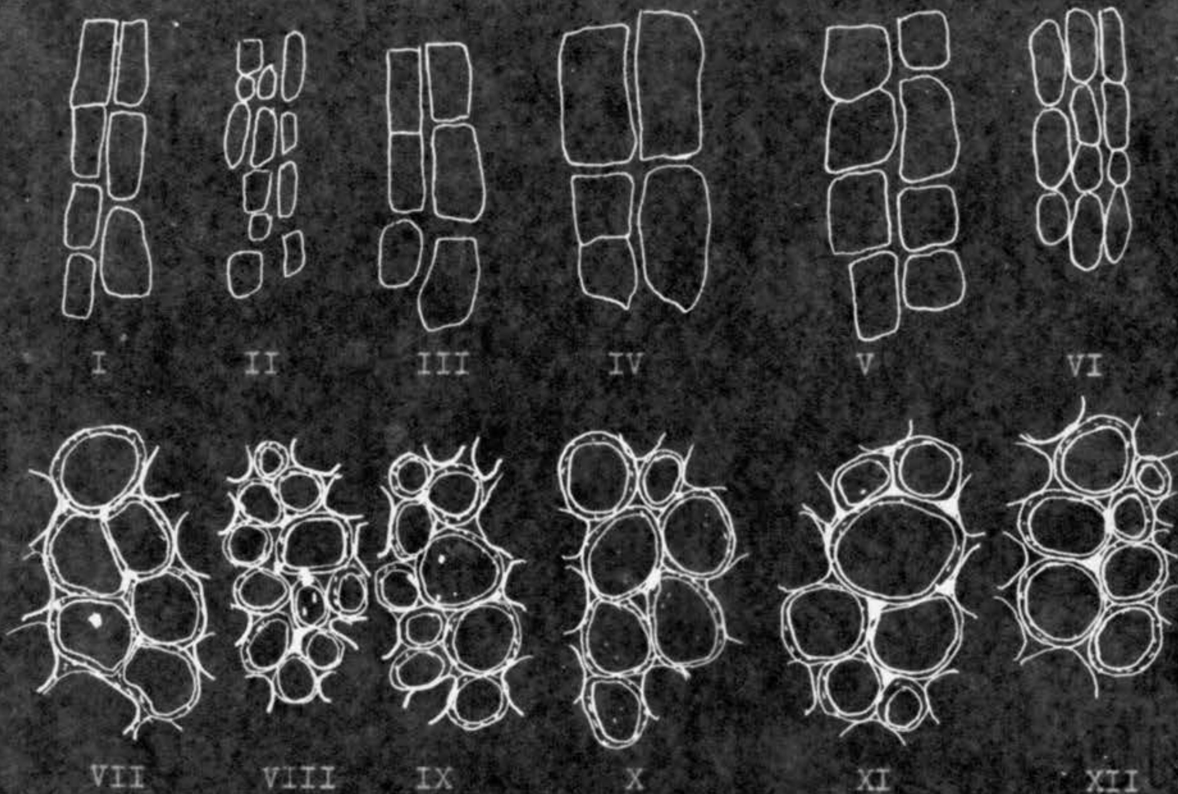
Results of two analyses, made by the Wolf "Rapid Determination" method, for the Staleymone treated plants are given in Table 1. The averages for the two analyses and that of the control are included. The samples were prepared at the same time and should be on a comparable basis. The Staleymone treated plants, for both varieties, were much higher in nitrate nitrogen than the control, but were lower or about the same for phosphorus, potassium, calcium, and magnesium. The above nutrients showed variations between samples, except magnesium, which remained fairly constant throughout the analysis.

Table 1. Analysis of the Corn Plant after Seed Treatment with Staleymone #16.

	RED JUNE CORN			WHITE JUNE CORN		
Chemical	Staley-mone	p.p.m.	Con-trol	Staley-mone	p.p.m.	Con-trol
Nitrogen	11.2		6.0	14.3		2.1
Phosphorus	4.9		5.0	4.4		4.6
Potassium	11.2		11.5	10.6		10.6
Calcium	32.5		37.2	25.0		33.2
Magnesium	4.1		4.1	4.0		4.0

Table 2. Analysis of the Corn Plant after Seed Treatment with Copper Aconitate.

	RED JUNE CORN			WHITE JUNE CORN		
Chemical	Copper Aconitate	p.p.m.	Con-trol	Copper Aconitate	p.p.m.	Con-trol
Nitrogen	2.1		6.0	6.2		2.1
Phosphorus	4.8		5.0	4.7		4.6
Potassium	9.0		11.5	11.0		10.6
Calcium	35.2		37.2	29.5		33.2
Magnesium	4.0		4.1	4.1		4.0



RED JUNE CORN

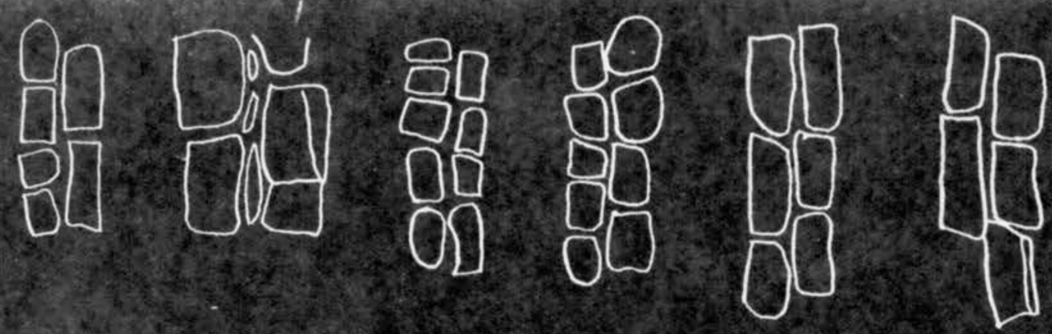
Greenhouse

Planted - May 10, 1943
Sectioned - May 24, 1943

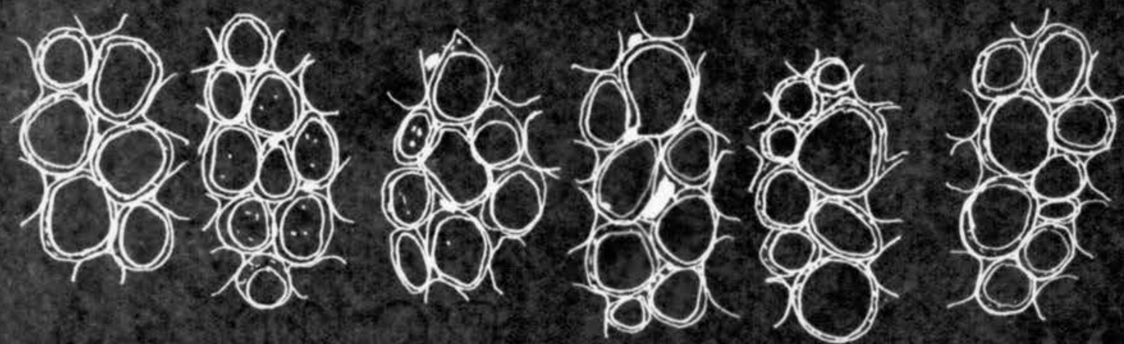
Longitudinal Sections
I. Normal Day Length - No Treatment
II. Short Day Length - No Treatment
III. Normal Day Length - Staleymone # 16
IV. Short Day Length - Staleymone # 16
V. Normal Day Length - Copper aconitate
VI. Short Day Length - Copper aconitate

Cross Sections
VII. Normal Day Length - No Treatment
VIII. Short Day Length - No Treatment
IX. Normal Day Length - Staleymone # 16
X. Short Day Length - Staleymone # 16
XI. Normal Day Length - Copper aconitate
XII. Short Day Length - Copper aconitate

PLATE I



I II III IV V VI



VII VIII IX X XI XII

WHITE JUNE CORN

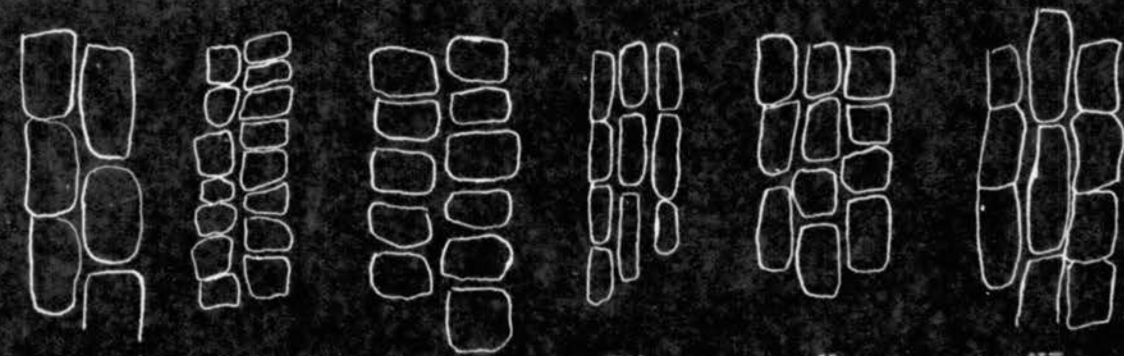
Greenhouse

Planted - May 10, 1943
Sectioned - May 24, 1943

Longitudinal Sections
- I. Normal Day Length - No Treatment
- II. Short Day Length - No Treatment
- III. Normal Day Length - Staleymone # 16
- IV: Short Day Length - Staleymone # 16
- V. Normal Day Length - Copper aconitate
- VI. Short Day Length - Copper aconitate

Cross Sections
- VII. Normal Day Length - No Treatment
- VIII. Short Day Length - No Treatment
- IX. Normal Day Length - Staleymone # 16
- X. Short Day Length - Staleymone # 16
- XI. Normal Day Length - Copper aconitate
- XII. Short Day Length - Copper aconitate

PLATE II



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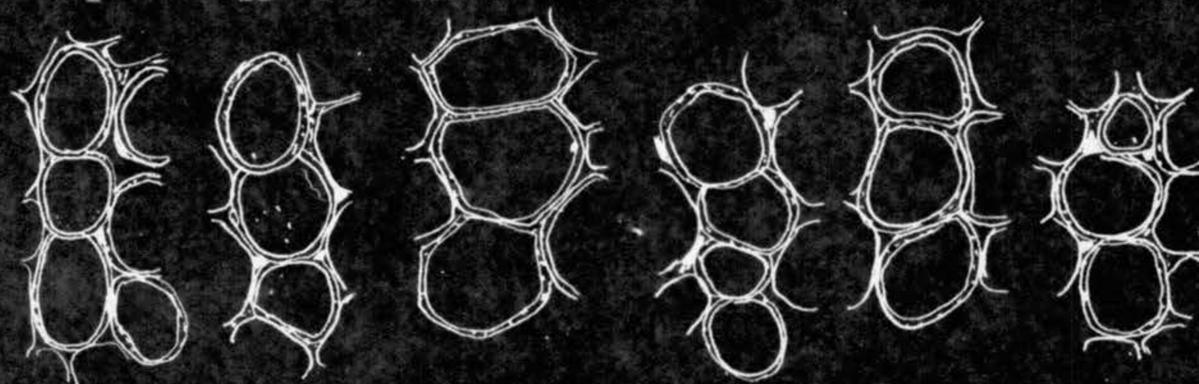


VII VIII IX X XI XII

RED JUNE CORN

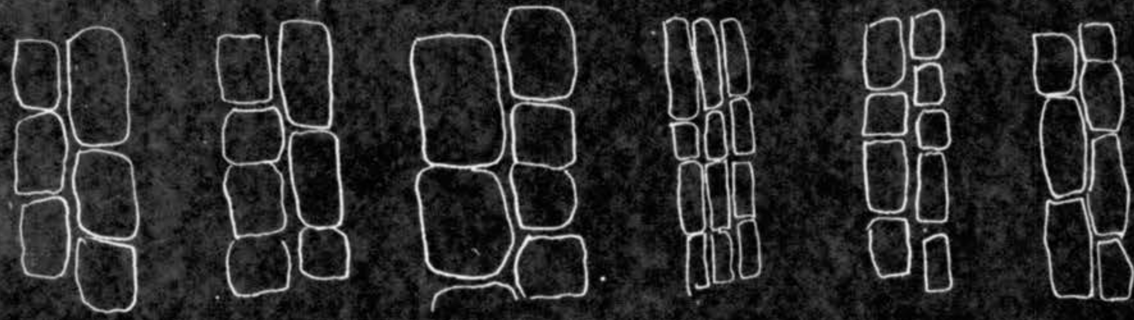
Greenhouse

Planted - May 10, 1943
Sectioned - June 3, 1943

Longitudinal Sections
- I. Normal Day Length - No Treatment
- II. Short Day Length - No Treatment
- III. Normal Day Length - Staleymone # 16
- IV. Short Day Length - Staleymone # 16
- V. Normal Day Length - Copper aconitate
- VI. Short Day Length - Copper aconitate

Cross Sections
- VII. Normal Day Length - No Treatment
- VIII. Short Day Length - No Treatment
- IX. Normal Day Length - Staleymone # 16
- X. Short Day Length - Staleymone # 16
- XI. Normal Day Length - Copper aconitate
- XII. Short Day Length - Copper aconitate

PLATE III



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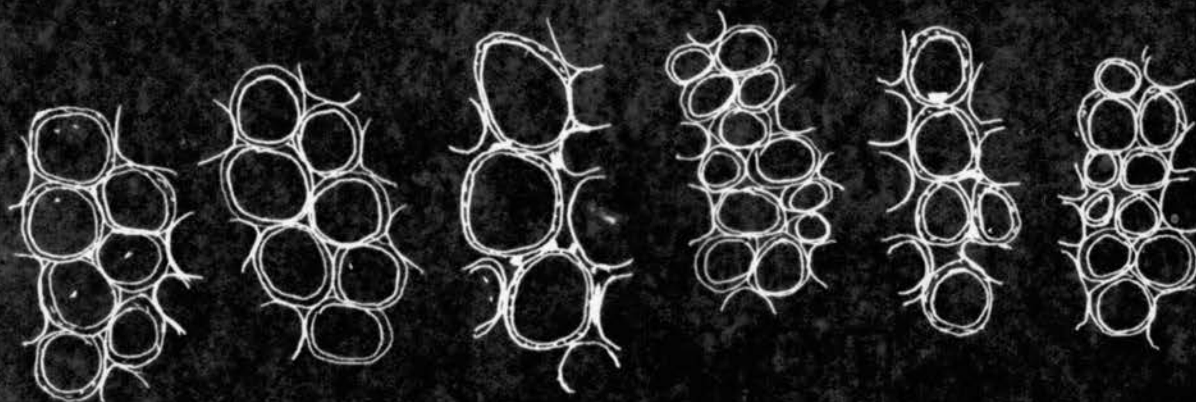

VII VIII IX X XI XII

WHITE JUNE CORN

Greenhouse

Planted - May 10, 1943
Sectioned - June 3, 1943

Longitudinal Sections
- I. Normal Day Length - No Treatment
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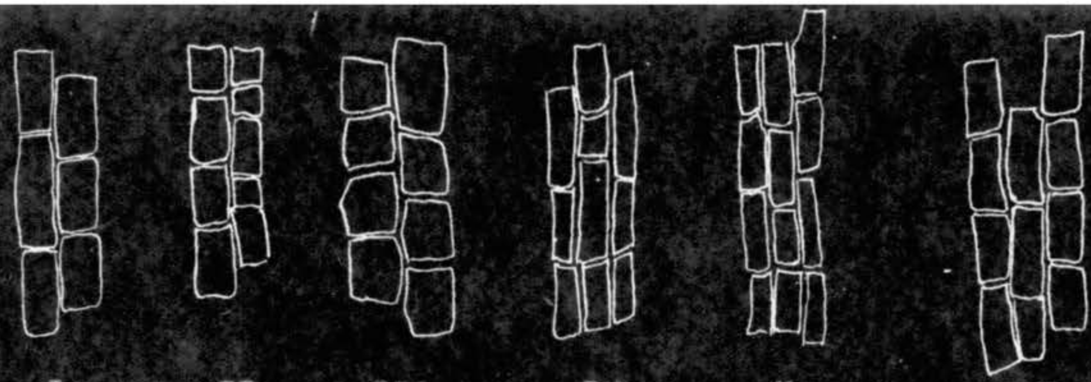
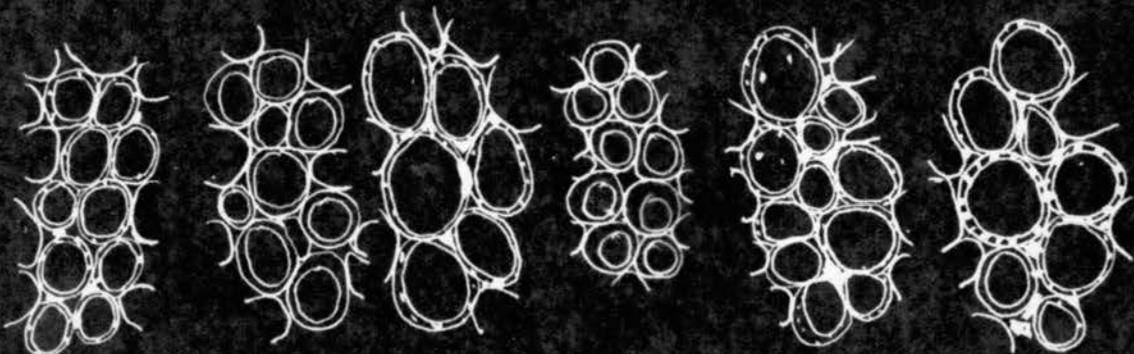
- IX. Normal Day Length - Staleymone # 16
- X. Short Day Length - Staleymone # 16
- XI. Normal Day Length - Copper aconitate
- XII. Short Day Length - Copper aconitate

PLATE IV





RED JUNE CORN

Greenhouse

Planted - June 25, 1943
Sectioned - July 3 , 1943

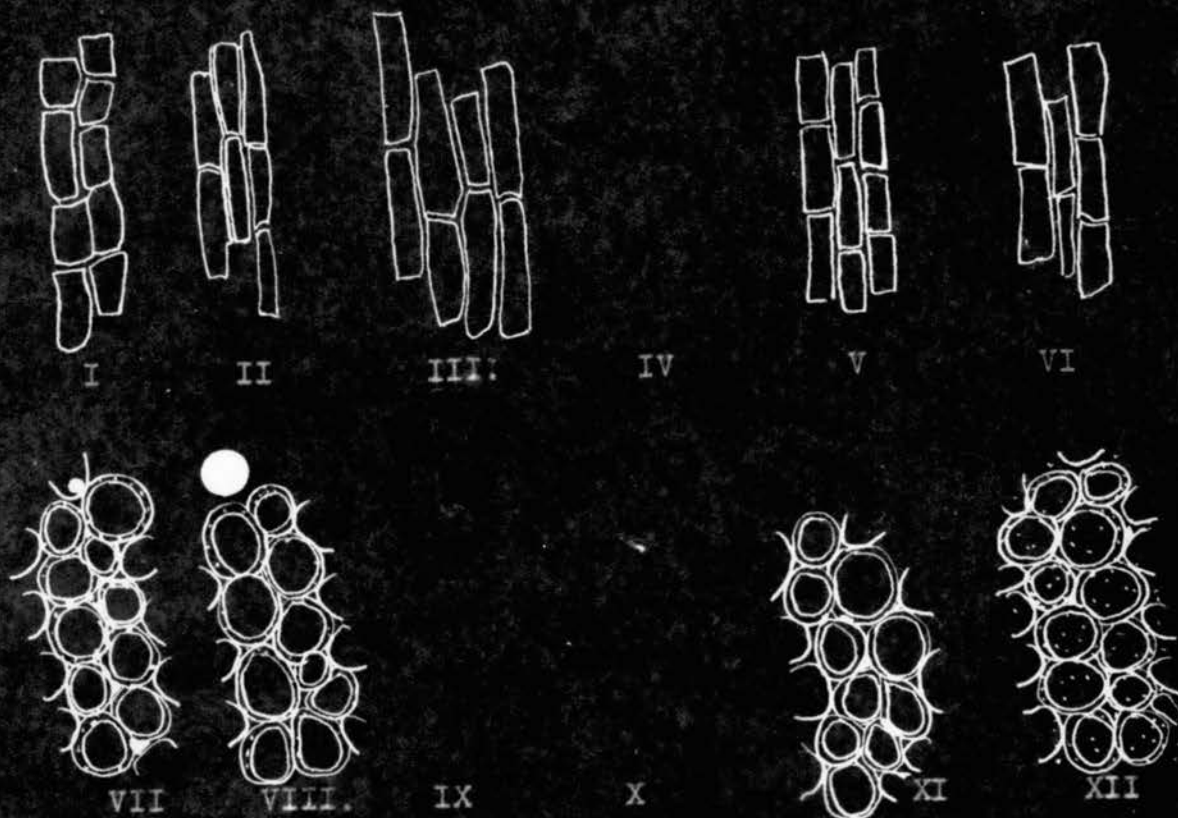
Longitudinal Sections

I. Normal Day Length - No Treatment
II. Short Day Length - No Treatment
III. Normal Day Length - Staleymone # 16
IV. Short Day Length - Staleymone # 16
V. Normal Day Length - Copper aconitate
VI. Short Day Length - Copper aconitate

Cross Sections

VII. Normal Day Length - No Treatment
VIII. Short Day Length - No Treatment
IX. Normal Day Length - Staleymone # 16
X. Short Day Length - Staleymone # 16
XI. Normal Day Length - Copper aconitate
XII. Short Day Length - Copper aconitate

PLATE V



WHITE JUNE CORN

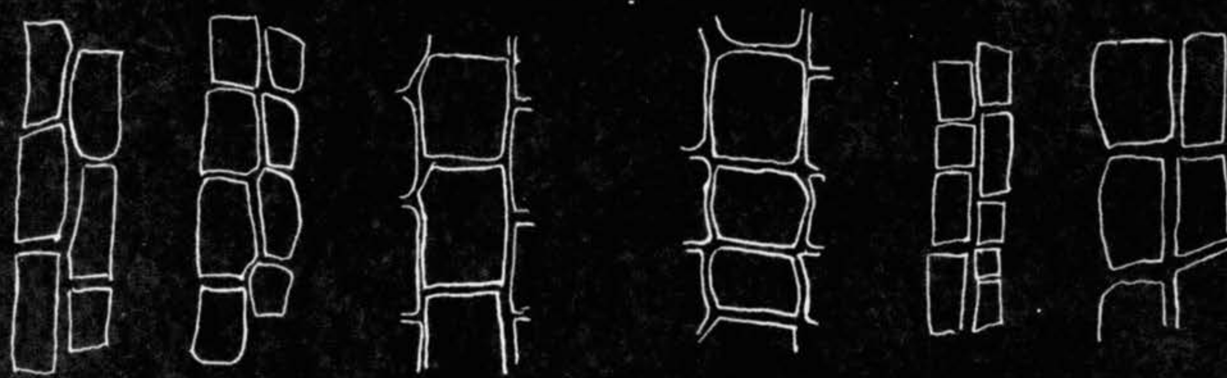
Greenhouse

Planted - June 25, 1943
Sectioned - July 3 , 1943

Longitudinal Sections
- I. Normal Day Length - No Treatment
- II. Short Day Length - No Treatment
- III. Normal Day Length - Staleymone # 16
- IV. Short Day Length - Staleymone # 16
- V. Normal Day Length - Copper aconitate
- VI. Short Day Length - Copper aconitate

Cross Sections
- VII. Normal Day Length - No Treatment
- VIII. Short Day Length - No Treatment
- IX. Normal Day Length - Staleymone # 16
- X. Short Day Length - Staleymone # 16
- XI. Normal Day Length - Copper aconitate
- XII. Short Day Length - Copper aconitate

PLATE VI



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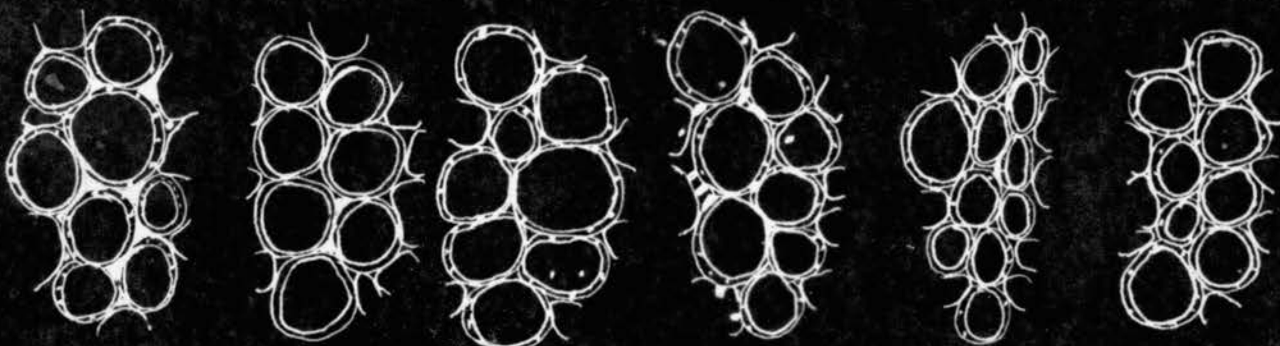


VII VIII IX X XI XII

RED JUNE CORN

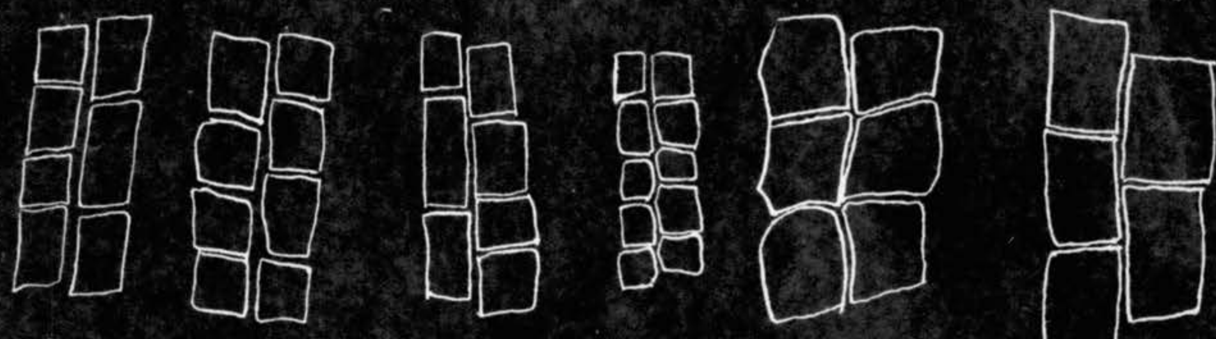
Greenhouse

Planted - June 25, 1943
Sectioned - July 16, 1943

Longitudinal Sections
- I. Normal Day Length - No Treatment
- II. Short Day Length - No Treatment
- III. Normal Day Length - Staleymone # 16
- IV. Short Day Length - Staleymone # 16
- V. Normal Day Length - Copper aconitate
- VI. Short Day Length - Copper aconitate

Cross Sections
- VII. Normal Day Length - No Treatment
- VIII. Short Day Length - No Treatment
- IX. Normal Day Length - Staleymone # 16
- X. Short Day Length - Staleymone # 16
- XI. Normal Day Length - Copper aconitate
- XII. Short Day Length - Copper aconitate

PLATE VII



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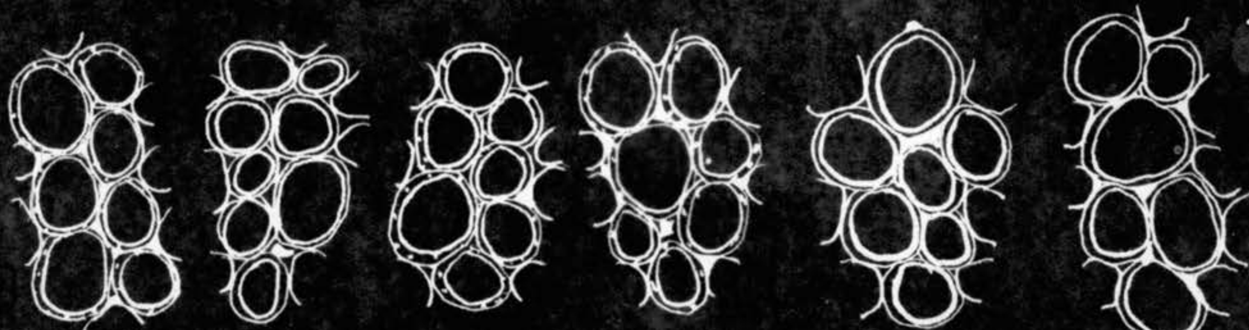

VII VIII IX X XI XII

WHITE JUNE CORN

Greenhouse

Planted - June 25, 1943
Sectioned - July 16, 1943

Longitudinal Sections
- I. Normal Day Length - No Treatment
- II. Short Day Length - No Treatment
- III. Normal Day Length - Staleymone # 16
- IV. Short Day Length - Staleymone # 16
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- IX. Normal Day Length - Staleymone # 16
- X. Short Day Length - Staleymone # 16
- XI. Normal Day Length - Copper aconitate
- XII. Short Day Length - Copper aconitate

PLATE VIII

Table 3. Analysis of Corn Plants Compared with Soil.

Chemical	RED JUNE CORN Plant	p.p.m.	Soil	WHITE JUNE CORN Plant	p.p.m.	Soil
Nitrogen	3.0		6.9	2.1		4.8
Phosphorus	5.1		7.5	4.6		7.1
Potassium	11.5		8.8	10.5		7.1
Calcium	37.2		73.0	33.2		65.9
Magnesium	4.1		6.5	4.0		6.1

The same information is given for the copper aconitate treated plants in Table 2. Here the analyses of the red corn for the treated plants were lower in each case than the control, but the treated white corn showed an increase over the control, except for calcium, which was lower. It may be possible that different varieties of crop plants will respond more readily than others to different growth promoting substances. The difference in response of the red and white varieties to treatment with copper aconitate would indicate the possibility.

Data obtained at the conclusion of each planting, as to the measurement and weights of plants and roots are given in Table 4. The data of the first planting were secured before the plants had begun to tassel, but, in order to observe possible differences in flowering, the second planting was left until practically all of the long day plants were showing tassels.

The results (Table 4) for the first planting are averages of the plants left in each pot. In the second planting, only one plant was left to the pot, but there were two pots of each and an average was taken of these. There is, in certain cases, a remarkable increase of treated plants over the control, but others are negative. These results vary in the same manner as those presented by the State College of Mississippi (23), where they weighed the roots, stems, and whole plants of differently treated seed of three different field crops. In the first planting, the Staleymone treated plants of the red variety averaged almost twice as much in weight

Figure 1. Corn exposed to normal day length.

Figure 2. Corn exposed to short day length.

of the plant as did the control. The weights of roots of the red corn and the plants in the white corn of the second planting, for this same treatment, were greatly increased.

Copper aconitate compared rather closely with the control, not greatly increasing or decreasing the results.

The per cent of dry weight was calculated for each treatment, but no great difference was found. (Table 7).

An inspection of Tables 1, 2, and 3 suggests that there may be varietal differences in the assimilation of nutrients. This is not materially changed by the treatment of the seeds by the growth regulators. With Staleymone, there is an apparent increase in nitrate nitrogen, which has been observed in other crops. The increase is to be expected in more vigorous vegetative processes. Other mineral differences are within the range of experimental error. This study has been made to provide information as to the theory that growth regulators may change the ratio of nutrient essentials in plants. The general conclusion may be drawn from these tabulations that on a percentage basis, mineral nutrients are not changed.

Table 4. Weights and Measurements of differently treated Plants.

Planting 1. Red		Height Inches Plants	Diameter Inches Plants	Weight Grams Plants	Weight Grams Roots
	Control	35.5	7/16	36.0	79.5
	Staleymone	30.0	12/16	70.0	55.0
	Copper aconitate	34.5	7/16	34.5	79.0
	White				
	Control	33.0	8/16	47.0	110.0
	Staleymone	27.0	7/16	44.5	45.0
	Copper aconitate	30.5	8/16	37.0	80.0
Planting 2. Red					
	Control	42.5	6/16	89.5	66.5
	Staleymone	44.0	6/16	87.5	95.5
	Copper aconitate	32.0	6/16	87.0	69.0
	White				
	Control	41.0	6/16	83.5	100.5
	Staleymone	48.5	7/16	103.0	84.5
	Copper aconitate	60.5	5/16	84.0	93.0

Length of Day

The corn used in studying the length of day, was planted and cared for in the same manner as that used in studying the effect of seed treatment. A large cardboard box, suspended from the ceiling by means of a pulley and rope, was used as a means of covering. No special arrangement was made for ventilation, but in covering the box several places were left through which air could pass. The interior was fairly dark, but no measurement was made to find just how much light was present.

The plants were covered at 5 P.M. and uncovered at 8 A.M., giving the short day plants exposure of nine hours daily.

Table 5. Analysis of Corn as Affected by Day Length.

	RED JUNE CORN			WHITE JUNE CORN		
Chemical	Long Day	p.p.m.	Short Day	Long Day	p.p.m.	Short Day
Nitrogen	3.0		12.6	2.1		13.2
Phosphorus	5.0		4.9	4.6		4.8
Potassium	11.5		12.7	10.6		10.2
Calcium	37.2		37.5	33.2		24.0
Magnesium	4.1		4.0	4.0		4.1

Table 5 suggests that the essential elements are not significantly affected by day length. The increase in nitrogen in the short day plants is in accord with the work of Murneek (26) in which he found a greater concentration of nitrate nitrogen in soybeans with short day.

Weights and measurements of the two day length exposure are given in Table 6. These were taken at the same time and in the same manner as those given in Table 4.

Table 6. Weights and Measurements of the Corn Plants as Affected by Length of Day.

Planting 1. Red		Height Inches Plants	Diameter Inches Plants	Weight Grams Plants	Weight Grams Roots
	Short Day	22.5	7/16	26.0	18.5
	Normal Day	35.0	7/16	36.0	79.0
	White				
	Short Day	31.0	8/16	27.5	11.0
	Normal Day	33.0	7/16	47.0	110.0
Planting 2. Red					
	Short Day	15.0	4/16	13.0	4.0
	Normal Day	42.5	6/16	89.5	66.5
	White				
	Short Day	21.0	6/16	36.0	14.0
	Normal Day	41.0	7/16	83.5	100.5

The height of the corn was very much restricted by exposing it to only nine hours of sunlight. The red corn was affected more by the short day than was the white. The white corn, in the first planting, showed only two inches difference in height, while the red showed a difference of 13 inches. The difference in height of the second planting was 20 inches for the white and 27 inches for the red. A corresponding increase of weight was found in the long day plant over the short day.

The covering of the plants had a profound effect upon root development. In each instance, the short day plants had a root development less

Figure 3. Long day plant (left) and short day plant (right) which show differences in growth of plant and root development.

Figure 4. The corn plant at the right was treated with Staleymone, the center plant with Copper aconitate, and a control at the left. All plants exposed to normal day length. Planted June 25, 1943, and photographed August 25, 1943.

Figure 5. The corn plant at the left was treated with Staleymone, the center plant with Copper aconitate, and a control at the right. All plants exposed to nine hours sunlight daily. Planted June 25, 1943, and photographed August 25, 1943.

in weight than the above-ground portion. With the long day plants, the opposite occurred. The per cent of dry weight was greater in the long day plants, than those exposed to only nine hours of sunlight, and less in the red than in the white.

Flowers appeared on the long day plants long before those exposed to the shorter light period. Although the plants were used for weights and measurements before the short day plants began to flower, the long day plants were all in tassel or the tassel was showing in the boot. This is in disagreement with the work of others (10) (22) (27), but as suggested before, this may be due to excluding the light, which would normally be at 4 P. M. Figures 1 and 2 show the difference due to day length.

Seed treatment, with growth promoting substances, had no effect on time of flowering. One of the Copper aconitate treated plants began to flower first, but others followed soon after. Wide differences in opinion exist in regard to the influence of various treatments on the time of flowering (17) (26).

Table 7. Per Cent Dry Weight of Plants Used in Analysis.

Red	Sample No. 1 % Dry Wt.	Sample No. 2 % Dry Wt.
Normal Day - No Treatment	8.0	8.0
Short Day - No Treatment	7.6	6.4
Normal Day - Staleymone #16	8.4	7.6
Short Day - Staleymone #16	6.0	6.0
Normal Day - Copper aconitate	7.6	9.2
Short Day - Copper aconitate	9.2	5.6
Average	7.8	7.3
White		
Normal Day - No Treatment	12.4	8.8
Short Day - No Treatment	8.8	6.8
Normal Day - Staleymone #16	7.6	8.4
Short Day - Staleymone #16	10.8	4.8
Normal Day - Copper aconitate	7.6	8.8
Short Day - Copper aconitate	8.8	8.4
Average	7.6	7.6

Table 7 is included to show the percentages of dry weights in comparison to green weights of the plants. On this basis, there is not a very significant difference between red corn and white corn.

SUMMARY

1. There is an increase in the size of seedlings when the seeds have been treated with Staleymone, accompanied by a corresponding increase in the size of the cells. Staining the freshly cut sections of the stems with toluidine blue differentiates small mitochondrial bodies within the cell walls. These are not very abundant in the untreated seedling, but they are prominent in the treated seedlings. This is in accord with the work of Borgstrom. It may be suggested that they are accretions from certain amino compounds. They are the nearest approach to endocrine deposits yet found in plants. This is not unusual in the growing tissues of animals.
2. An increase in nitrate nitrogen has been noted in several other publications, and it seems to be a characteristic of hormone stimulation. This is not the case with other essential elements.
3. Copper aconitate does not seem to be very effective as a growth regulator. Where the growth depends upon the presence of copper, it may represent a source of supply for plants, as it has in hydroponic growing of plants.
4. The length of day as a source of influencing the response to growth regulators was not a factor. Since corn is normally a long-day plant, the differences in development are those found in short-day exposures, contrasted with those of the long day. Short-day exposures delayed the time of flowering.

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